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2,887,528

COLOR TELEVISION RECEIVING SYSTEM

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2 Sheets-Sheet 1

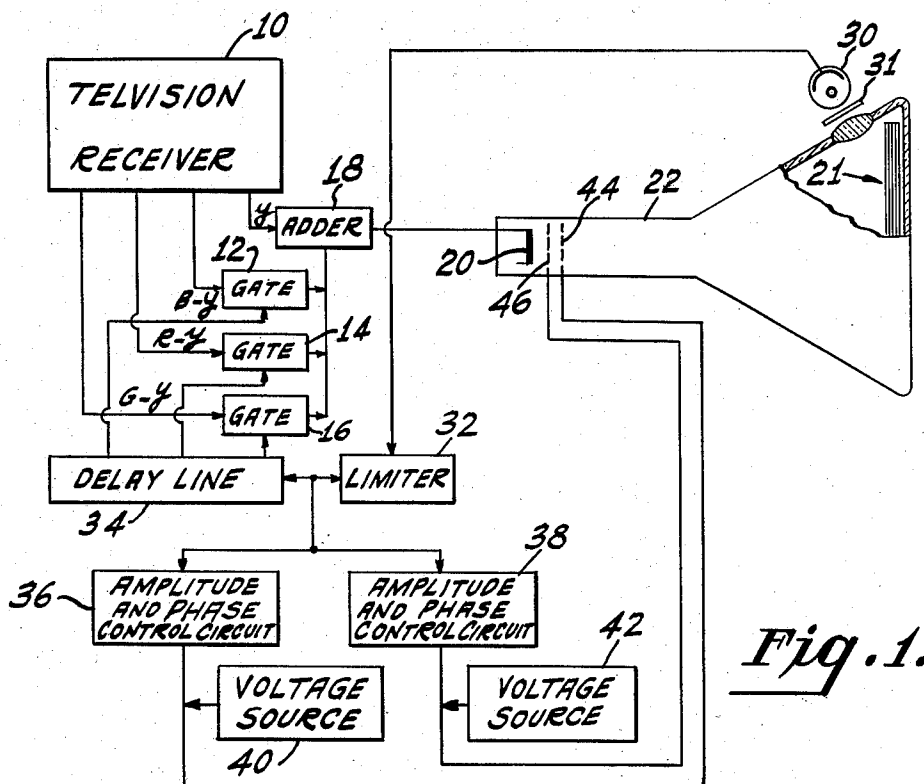


Fig. 1.

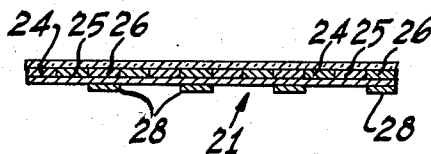


Fig. 1A.

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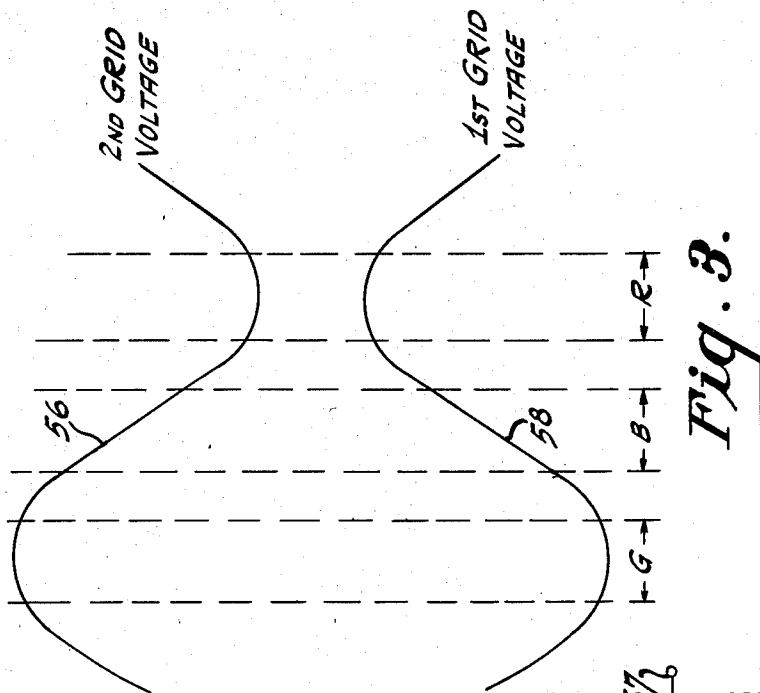


Fig. 3.

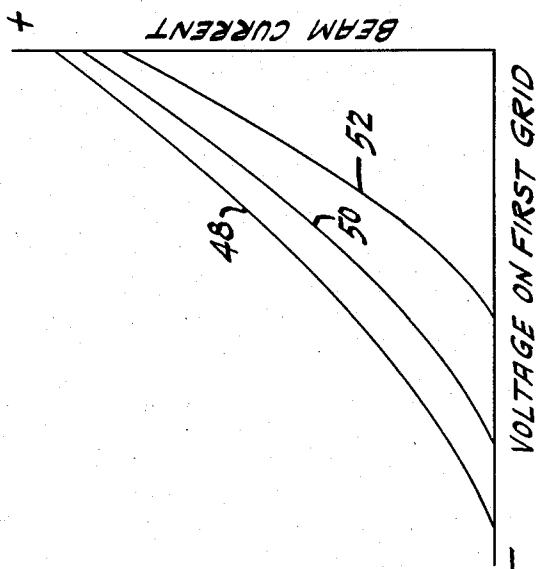


Fig. 2.

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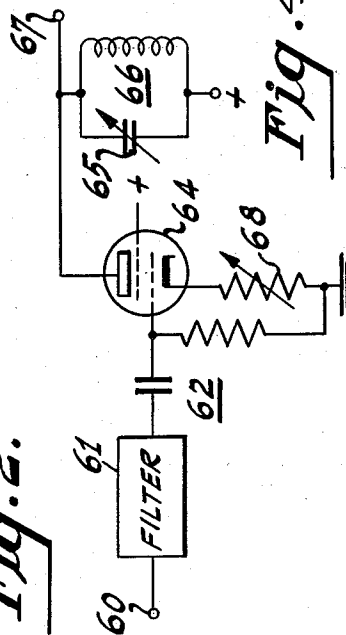


Fig. 4.

AMPLITUDE AND PHASE CONTROL CIRCUIT

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2,887,528

COLOR TELEVISION RECEIVING SYSTEM

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Application September 1, 1954, Serial No. 453,580

11 Claims. (Cl. 178—5.4)

This invention relates to color television and more particularly to arrangements for providing improved reproduction of images in substantially their natural color.

In the luminescent screens of certain types of multi-color image reproducing devices used in the reproduction of images in substantially their natural color, materials are utilized which emit light of particular component colors upon being excited by electron beam energy. A difficulty is encountered in the use of such light producing materials in that the materials presently utilized for producing the different light colors generally do not all have the same efficiency. If an electron beam of a particular intensity is used to excite the different light producing materials or phosphors, the intensity of the light emanating from the different phosphors will generally not be the same. By reason of the phosphor efficiency differences in the video signals representative of the colors in the image to be reproduced will not be effective in reproducing a true image upon being converted into light.

It has been proposed to overcome this difficulty, in image reproducing systems utilizing image reproducing devices having three electron beams, by imparting a higher beam current operating range to the electron beam which is utilized to excite the least efficient light producing material or phosphor element. The variations in beam current operating range may be effected by varying the voltages applied to the different grid electrodes controlling the separate electron beams.

In varying the voltages applied to the grid electrodes of the separate electron beams, the characteristics of the individual electron beams are altered in such a manner that they do not coincide at the level of video signal where no light will be produced, i.e., black level. To compensate for the variations in coincidence between the black level of the separate electron beams, another group of grid electrodes within the image, reproducing tube, each of which is associated with a separate one of the electron beams, may be held at a different potential control.

In regard to an image reproducing device utilizing a single electron beam the variations in efficiency of the light producing or phosphor materials are still present. However, the single set of grid electrodes operated in a conventional manner, will change the characteristics of the single beam utilized for all of the colors reproduced.

The present invention in its more general form has applications to a color image reproducing device utilizing a single electron beam to scan a target electrode. The target electrode is provided with different elements to produce different component colors of light upon being excited by the electron beam. A method and an apparatus for compensating for any efficiency differences between the different elements is provided as follows. A control signal is formed by the electron beam striking certain signal-generating elements on the target electrode. The elements from which the control signal is formed are so positioned as to cause the control signal to be indicative of the relative position of the electron beam with respect

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to the different light-producing elements. The control signal is then utilized to generate a group of characteristic changing signals (e.g., voltages) which are then used to vary the characteristics of the electron beam depending upon which of the particular component color light producing elements the electron beam is exciting. The beam current operating range of the electron beam is thus made different for each of the light producing elements to compensate for the efficiency differences of the different phosphors, and the black level, i.e., the value of video signal at which the beam current will be zero, is made the same for each light producing element.

An object of this invention is to provide improved reproduction of television images in substantially their natural color.

Another object of this invention is to provide improved color image reproduction in an image reproducing device of the type employing a single electron beam.

A further object of this invention is to provide a system to compensate effectively for variations in efficiency of different light producing elements in a color image reproducing device of the type utilizing a single electron beam.

Other and incidental objects of this invention will be apparent to those skilled in the art from reading the following specification and on inspection of the accompanying drawings in which;

Figure 1 shows a schematic and block diagram of a form of the invention.

Figure 1A shows a form of image reproducing screen which may be used in the system shown in Figure 1.

Figure 2 shows curves which are utilized for an explanation of the system of the invention.

Figure 3 shows curves, representative of signals generated within the system of Figure 1.

Figure 4 shows one form of amplitude and phase control circuit which may be used in the system of Figure 1.

Referring now to Figure 1 there is shown a television receiver of the type which may be used to receive a transmitted color television signal and deliver four color television image component signals, a brightness or Y signal, a color difference signal B—Y, a color difference signal R—Y, and a color difference signal G—Y. Such a television receiver is shown and described in an article appearing in "Electronics" magazine, February 1952, entitled "Principles of NTSC Compatible Color Television."

The color difference signals B—Y, R—Y, and G—Y, when individually added to the Y or brightness signal will result respectively in a blue representative signal, a red representative signal, and a green representative signal, each being indicative of the component color present in the color image to be reproduced. The color difference signals B—Y, R—Y and G—Y are respectively connected to gate circuits 12, 14 and 16 wherein their sequential application to an adder circuit 18 is controlled. The adder circuit 18 is also connected to receive the Y or brightness signal from the television receiver 10. The output from the adder circuit 18 thus contains sequentially appearing representation of the different color representative signals. The output from the adder circuit 18 is applied to the cathode 20 of an image reproducing tube 22 to sequentially intensity modulate an electron beam with the different color representative signals.

The target electrode 21 of the image reproducing tube 22, i.e. kinescope, is shown fragmentarily in Figure 1A to an enlarged scale, and is of the type shown and described in U.S. Patent No. 2,633,547, issued March 31, 1954 to H. B. Law. The screen shown in Figure 1A contains color reproducing strip-like elements 24, 25 and 26, each for producing a component image color upon being excited by an electron beam. In addition, control signal

generating strip-like electron-transparent elements 28 are positioned on the image reproducing target electrode and are utilized to generate a control signal upon being excited by the electron beam. The control signal generating strips are so fixed as to emit control signals even when the electron beam is of such intensity as to not excite the color reproducing strip-like elements 24, 25 and 26 to a visible degree. The control signal generated by the electron beam crossing the signal generating elements 28 is therefore indicative of the position of the electron beam with respect to the strip-like elements. The signal generating elements 28 may be composed of ultra violet light emitting phosphor, in which event the ultra violet light so emitted is sensed through an ultra violet light passing filter 31, by a photoelectric cell 30 positioned exterior to the image reproducing tube 22. Signals sensed by the photoelectric cell 30 are then fed to a limiter circuit 32 wherein they are limited in amplitude, and thence coupled to a delay line 34. The limiter circuit 32 serves to regulate the amplitude of the signals sensed by the photoelectric cell 30, regardless of beam intensity variations. The delay line 34 is tapped at various points to derive three different phase shifted voltages, each being phase shifted substantially 120° from the others. The different voltages tapped from the delay line 34 are applied to the respective gate circuits 12, 14 and 16 in such a manner as to control the sequential application of the color difference signals B—Y, R—Y, and G—Y to the adder circuit 18. A similar switching system is shown and described in U.S. Patent No. 2,545,325, issued March 13, 1951, to P. K. Weimer.

The limiter circuit 32 also has an output which is connected to two amplitude and phase control circuits 36 and 38. The amplitude and phase of the signals from the limiter 32 may be individually adjusted in the two amplitude and phase control circuits 36 and 38. The signal voltages derived from the amplitude and phase control circuits 36 and 38 are then added with voltages from positive voltage source 40 and negative voltage source 42 respectively and applied respectively to a second grid 44 and a first grid 46 of the image reproducing tube 22.

As the color signals derived from the adder circuit 18 are applied, in a sequential manner, to the cathode 20 of the image reproducing tube 22, the intensity of the light emitted from the color reproducing phosphor elements 24, 25 and 26 of the screen 21 will not be of like intensity for the same intensity of electron beam energy. The variation in light emission is due to the efficiency differences between the phosphor materials. To compensate for this variation it is necessary to vary the operating range or characteristic of the electron beam as it excites the different color reproducing phosphor elements.

Referring now to Figure 2 there are shown various curves representative of operating characteristics of the electron beam of the image reproducing tube 22. Beam current is plotted as ordinate and the voltage on the first grid 46 is plotted as abscissa. Various curves 48, 50 and 52 are shown, each being indicative of a different value of voltage on the second grid 44. The curve 48 is shown with a relatively high positive voltage on the second grid 44. The curve 50 is shown with mid-value positive voltage on the second grid 44 and a third curve 52 is shown with a positive voltage on the second grid 44 which is relatively low. In the event a variation in voltage is brought about on the second grid 44 when it is desired to reproduce a different component color, it may be seen that a different one of the curves 48, 50, or 52 will represent the operating characteristic of the electron beam of the image reproducing tube 22. The various curves 48, 50, and 52 shown in Figure 2 have different rates of change and a variation in the voltage applied to the second grid 44 will therefore cause a different value of beam current to be emitted for a particu-

lar level of a video signal to thereby compensate for phosphor efficiency differences.

The variation in voltage at the second grid 44 will also alter the black level value of the video signal impressed upon the tube. For three different operating curves which might be used to compensate for efficiency differences between three different light producing materials, three different black levels or beam cutoff potentials would be encountered. Reproduction of colors in the gray range would thus be difficult due to the lack of coincidence between the three different black levels of the three different colors produced. The three different operating characteristics may be made to substantially match at the same black level by varying the voltage on the first grid 46. Stated another way, in the event different voltages are applied to the second grid 44 of the tube 22, to compensate for variations in efficiencies between the color reproducing elements, different black levels will be present for each of the different colors. To compensate for the variations in black level, variations in voltages applied to the first grid 46 may be utilized which will set the black level substantially the same for each of the different color reproducing elements of the screen 21.

The black level compensation may be explained more readily with reference to Figure 2 and the curves 48, 50, and 52. Consider first the period during which the electron beam is producing red component light. During this period it may be desirable to operate the electron beam of the tube 22 on curve 52 by the impression of a suitable voltage on the second grid 44. Such operation will impart a character to the electron beam, because of the relative slope of curve 52, which will cause the beam current to be of a higher magnitude for a particular video signal than during operation on say curves 50 or 48. The operation on the curve 52 will cause the black level of the tube to be at a particular value. If the voltage on the second grid 44 is now altered to reproduce another color, a different beam, characteristic such as either of curves 48 or 50 will represent the operating range of the electron beam of the tube 22, and a different black level must be set. To cause the black level to be at the same value for operation on any of the curves 48, 50 and 52 the voltage on the first grid 46 is altered for each different voltage applied to the second grid 44.

It may therefore be seen that it is desirable in order to compensate for the various efficiency differences between the phosphors to vary both the voltage applied to the second grid 44 and the voltage applied to the first grid 46 as the electron beam excites elements of the screen 21 which reproduce different ones of the component colors.

Referring now to Figure 3, there are shown curves 56 and 58. Curve 56 is representative of the characteristic changing voltage which is applied from the amplitude and phase control circuit 36 with a positive unvarying bias voltage from the positive voltage source 40 to the second grid electrode 44. The curve 58 is representative of the characteristic changing voltage which is applied from the amplitude and phase control circuit 38 with a negative unvarying bias voltage from the negative voltage source 42 to the first grid electrode 46 of the image reproducing tube 22.

For the time during which the curves 56 and 58 lie within the G period, during which the image reproducing tube 22 reproduces green component color, the second grid electrode 44 receives a relatively high positive characteristic changing voltage, thereby causing the electron beam characteristic to be similar to that shown in curve 48 of Figure 2. Also during the green or G period, the characteristic changing voltage applied to the first grid electrode 46 as shown in curve 58 of Figure 3 has a relatively low positive value, thus causing the beam during the period when green light is produced to have a certain black level.

During the B period when blue light is being produced,

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the characteristic of the electron beam is shifted to operate substantially on the curve 50 of Figure 2 by applying a medium value voltage to the second grid 44, as indicated by the curve 56 of Figure 3, thereby causing the beam to have a different black level than during the green color producing period G. The different black level is made to coincide with that existent during the G period by applying a medium value voltage to the first grid 46, as shown in curve 58 of Figure 3.

During the time when the image reproducing tube is producing red light, the R period, the second grid 44 will receive a relatively low positive voltage as shown in the curve 56 of Figure 3, thereby causing the beam operating characteristic to be substantially as shown in curve 52 of Figure 2. The decrease in positive voltage applied to the second grid 44 results from the decrease of the voltage from amplitude and phase control circuit 36 which is added to the unvarying positive voltage from the voltage source 40. During this period, however, the first grid electrode 46 will receive a voltage, as shown in curve 56 combined with a negative voltage from the voltage source 40, thereby causing the tube to operate substantially at the same black level as during the other periods of color reproduction.

It may therefore be seen that during a period when, the image reproducing tube is producing a particular color light, the beam characteristic will be changed by changing the positive bias voltage applied to the second grid electrode 44. However, the variation in operating range results in a change in the black level value, of the beam. To maintain the black level value the same for all colors produced, a variation in the negative bias voltage applied to the first grid electrode 46 is made.

Referring now to Figure 4, there is shown a form of a circuit which may be utilized as the amplitude and phase control circuits 36 and 38 of Figure 1. There is shown an input terminal 60 for receiving signals from the limiter 32. The signals applied at the input terminal 60 are applied to a filter 61 to provide a sinusoidal waveform from the pulsating control signal. The sine wave from the filter 61 is applied to an input circuit 62 and thence to a control grid of an electron discharge device 64. The output from the anode electrode of the electron discharge device 64 is coupled to a variable inductance-capacitance circuit 66 and thence to a source of positive potential. The cathode circuit of the electron discharge device 64 is coupled through a variable resistor 68 to a source of reference potential. Signals of substantially sine waveform which appear at the control grid electrode of the electron discharge device 64 may be varied in amplitude by varying the variable resistor 68 which will vary the cathode voltage of the electron discharge device 64, to thereby vary the current through the electron discharge device 64, and the degeneration effect. The signals may be varied in phase by varying the variable capacitor 65 of the inductance-capacitance circuit 66. Variation of variable capacitor 65 varies the phase of the output voltage appearing at an output terminal 67. The circuit shown in Figure 4 may therefore be utilized to generate either of the signals as shown in curves 56 and 58 of Figure 3.

It may be desirable in another form of the invention to cause the curves 58 and 56 to be substantially instantaneous in their variations such that a three step waveform function is utilized rather than a sinusoidally varying waveform. In such an event the amplitude and phase control circuits 36 and 38 will additionally contain one of the various well known forms of step waveform generators which will generate a three level step voltage from the sine waveform.

It may therefore be seen that the invention provides an improved system for compensating for variations in the efficiency of light emitting materials which may be utilized in an image reproducing device having a single electron beam.

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I claim:

1. In a color television system wherein an electron beam is sequentially modulated in intensity by color-representative signals and is utilized to excite color light producing elements of an image reproducing device, means for compensating for variations in the efficiency between said color light producing elements comprising; means for generating a control signal, said control signal being indicative of the position of said electron beam with respect to said color light producing elements; means for generating beam controlling signals in response to said control signal; means for varying the intensity of said electron beam; and means applying said beam controlling signals to said means for varying the intensity of said electron beam, such that when certain of said color light producing elements are being excited said electron beam has a particular characteristic, and when other of said color light producing elements are excited, said electron beam is of a different character.

2. A device according to claim 1 wherein said means for generating beam controlling signals in response to said control signal comprises; a plurality of amplitude and phase control circuits.

3. A device according to claim 1 wherein said means for varying the intensity of said electron beam comprises; a plurality of grid electrodes of said image reproducing device.

4. In combination with a color kinescope having a plurality of groups of strip-like light producing elements for producing light of a component image color upon being excited by an electron beam which is sequentially modulated in intensity by color-representative video signals, means for generating a control signal representative of the position of said electron beam with respect to said light producing elements, beam characteristic signal generating means connected to receive said control signals for generating a plurality of periodic beam characteristic changing signals in response to said control signal, beam intensity control means connected to receive said beam characteristic changing signals such that during the time interval when said beam impinges on certain elements of a group of said groups of light producing elements, said beam intensity control means receives certain of said beam characteristic changing signals.

5. In combination with a color kinescope having a plurality of groups of light producing elements, each of said groups of light producing elements for producing light of a component image color upon being excited by an electron beam which is sequentially modulated in intensity by color-representative video signals, means for generating a control signal representative of the position of said electron beam with respect to said light-producing elements, means adapted to receive said control signal for generating in response thereto a first and a second electron beam characteristic changing signal, first and second electron beam controlling means, and means for applying said first electron beam control signal to said first electron beam controlling means, and for applying said second electron beam control signal to said second electron beam controlling means such that the beam current versus video drive characteristics of said beam are varied as said electron beam impinges upon elements of different of said groups of strip-like elements.

6. In combination with a color kinescope having a plurality of groups of light producing elements, each of said groups of light producing strip-like elements for producing light of a component image color upon being excited by an electron beam, means for generating a control signal representative of the position of said electron beam with respect to said strip-like elements, means adapted to receive said control signal for generating in response thereto a first and a second electron beam characteristic changing signal, first and second grid electrode means, means for applying to said first grid electrode means a video drive voltage which is sequentially

representative of the component colors of such image, means for applying said first electron beam controlling signal to said first grid electrode, and means for applying said second electron beam controlling signal to said second grid electrode, such that the beam current versus first grid drive characteristics of said beam are varied as said electron beam impinges on elements of different of said groups of strip-like elements.

7. In combination with a color kinescope having a plurality of groups of light producing elements, each of said groups of light producing elements for producing light of a component image color upon being excited by an electron beam which is sequentially modulated in intensity by color-representative video signals, signal generating strip-like elements interlaid with said light producing elements for generating a control signal upon being excited by an electron beam, said control signal being indicative of the position of said electron beam with respect to said light producing elements, beam intensity control means for controlling the intensity of said electron beam, beam characteristic changing signal generating means connected to receive said control signal for generating a plurality of beam characteristic changing signals in response to said control signal, means applying said beam characteristic changing signal generating means to said beam intensity control means such that during the time interval when said electron beam impinges on an element of one of said groups of elements, said beam intensity control means will receive particular beam current versus video drive beam characteristic changing signals.

8. In combination with a color kinescope having a plurality of groups of light producing elements for producing light of a component image color upon being excited by an electron beam, means for generating a control signal, said control signal being indicative of the position of said electron beam with respect to said light producing elements, modulating means for modulating said electron beam, switching means connected to be controlled by said control signal for sequentially coupling different component color video signals to said modulating means, beam intensity control means for controlling the intensity of said electron beam, beam characteristic signal apparatus for generating a plurality of beam characteristic changing signals in response to said control signal, means connecting said beam characteristic signal generating means to said beam intensity control means such that during the period when said electron beam impinges on an element of one of said groups of elements, said beam intensity control means will receive a particular beam current versus video drive characteristic changing signal.

9. A color television image reproducing system comprising in combination an image screen having a plurality of groups of light producing elements, each of said groups of elements for producing light of a component color upon being excited by an electron beam, said image screen having a plurality of signal generating elements for generating a control signal upon being excited by said electron beam, said control signal being indicative of the scanning position of said electron beam, beam modulating means for sequentially intensity modulating said electron beam with in response to different one of a plurality of video color signals as said electron beam impinges

upon in response to different one of said light producing elements, control means for controlling the character of said electron beam, phase shift means connected to receive said control signal for generating a plurality of phase shifted signals, means connecting said phase shifted signals to said beam control means such that electron beam shall have a predetermined beam current versus video drive character when said electron beam excites said light producing elements of certain of said groups of light producing elements.

10. A color television image reproducing system comprising in combination an image screen having a plurality of groups of light producing elements, each of said groups of elements for producing light of a component color upon being excited by an electron beam, said image screen having a plurality of signal generating elements for generating a control signal upon being excited by said electron beam, said control signal being indicative of the scanning position of said electron beam, beam modulating means for sequentially intensity modulating said electron beam with different of a plurality of video color signals as said electron beam impinges upon different of said light producing elements, first and second control means for controlling the character of said electron beam, phase shift means connected to receive said control signal for generating a plurality of phase shifted signals, means connecting said phase shift signal to said first and said second beam control means such that said electron beam shall be of a predetermined character when said electron beam excites said light producing elements of certain of said groups of said light producing elements.

11. A color television image reproducing system comprising in combination an image screen having a plurality of groups of light producing elements, each of said groups of elements for producing light of a component color upon being excited by an electron beam, said image screen having a plurality of signal generating elements for generating a control signal upon being excited by said electron beam, said control signal being indicative of the scanning position of said electron beam, beam modulating means for sequentially intensity modulating said electron beam with different of a plurality of video color signals as said electron beam impinges upon different of said light producing elements, a first control electrode and a second control electrode for controlling the character of said electron beam, phase shift means connected to receive said control signal for generating a first and second phase shifted signal, means connecting said first shifted signal to said first control electrode and said second phase shifted signal to said second control electrode such that said electron beam shall be of a predetermined character when said electron beam excites said light producing elements of a certain of said groups of light producing elements.

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